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(54) **Title:** PROCESS AND SYSTEM FOR LASER CRYSTALLIZATION PROCESSING OF FILM REGIONS ON A SUBSTRATE TO MINIMIZE EDGE AREAS, AND STRUCTURE OF SUCH FILM REGIONS
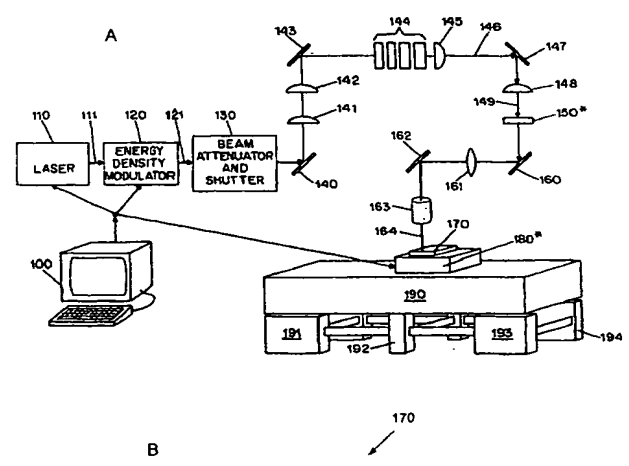
(57) **Abstract:** A process and system for processing a thin film sample are provided. In particular, a beam generator can be controlled to emit at least one beam pulse. The beam pulse is then masked to produce at least one masked beam pulse, which is used to irradiate at least one portion of the thin film sample. With the at least one masked beam pulse, the portion of the film sample is irradiated with sufficient intensity for such portion to later crystallize. This portion of the film sample is allowed to crystallize so as to be composed of a first area and a second area. Upon the crystallization thereof, the first area includes a first set of grains, and the second area includes a second set of grains whose at least one characteristic is different from at least one characteristic of the second set of grains. The first area surrounds the second area, and is configured to allow an active region of a thin-film transistor ("TFT") to be provided at a distance therefrom.
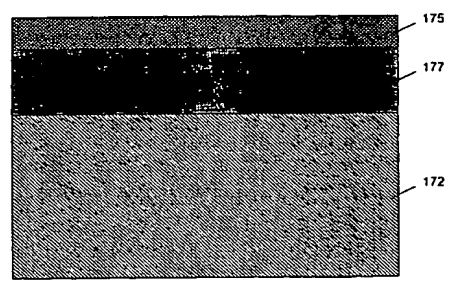
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PROCESS AND SYSTEM FOR LASER CRYSTALLIZATION PROCESSING OF FILM REGIONS ON A SUBSTRATE TO MINIMIZE EDGE AREAS, AND STRUCTURE OF SUCH FILM REGIONS

SPECIFICATION

5   **RELATED APPLICATION**

This application claims priority to United States Provisional Application No. 60/405,085, which was filed on August 19, 2002, and is incorporated by reference.

NOTICE OF GOVERNMENT RIGHTS

10   The U.S. Government may have certain rights in this invention pursuant to the terms of the Defense Advanced Research Project Agency award number N66001-98-1-8913.

FIELD OF THE INVENTION

The present invention relates to techniques for processing of thin films,
15   and more particularly to techniques for processing semiconductor thin films to reduce non-uniform edge areas of the crystallized regions of the thin film so that at least an active region of an electronic devices, such as a thin-film transistor ("TFT"), can be placed away from such non-uniform edge areas.

BACKGROUND OF THE INVENTION

20   Semiconductor films, such as silicon films, are known to be used for providing pixels for liquid crystal display devices and organic light emitting diode displays. Such films have previously been processed (i.e., irradiated by an excimer laser and then crystallized) via excimer laser annealing ("ELA") methods. However, the semiconductor films processed using such known ELA methods often suffer from
25   microstructural non-uniformities such as edge effects, which manifest themselves in availing a non-uniform performance of thin-film transistor ("TFT") devices fabricated on such films.

Such non-uniformity in edge regions is particularly problematic in that the visual transitions between the neighboring pixels corresponding to the irradiated and crystallized areas of the semiconductor thin film on the liquid crystal displays ("LCDs") or organic light emitting diode displays are not as smooth as could be

5   desired, and may even be visible in certain cases, which is undesired. This is also because the edge effects promote a low performance in TFT devices whose active regions are provided thereon.

Significant efforts have been made into the refinement of "conventional" ELA (also known as line-beam ELA) processes in the attempt to

10   reduce or eliminate non-uniformities on the crystallized areas of the semiconductor thin film. For example, U.S. Patent No. 5,766,989 issued to Maegawa et al., the entire disclosure of which is incorporated herein in its entirety by reference, describes the ELA methods for forming polycrystalline thin film and a method for fabricating a thin-film transistor. This publication attempts to address the problem of non-

15   uniformity of characteristics across the substrate, and provide certain options for apparently suppressing such non-uniformities. However, details of previous approaches make it impossible to completely eliminate the non-uniformities that are introduced from the edge areas (which are typically between 100μm to 1,000μm or higher). Thus, the cross sectional area of the portions of the semiconductor thin film

20   on which the TFT devices could be placed would be significantly reduced due to such disadvantageous edge effects causing large non-uniform edge areas which border these portions.

For example, one such conventional ELA process uses a long and narrow shaped beam 800 as shown in Figs. 11A and 11B. The fluence of this beam

25   800 is above a melting level in a center portion 810 thereof, while side areas 820 of this beam 800 have a fluence that is gradually reduced at the edges thereof. The width of the center portion 810 of the beam 800 may be 1cm and the length thereof may be 30cm. In this manner, the beam can potentially irradiate the entire semiconductor thin film during one pass across it. As shown in Fig. 11B, portions 830 of the side areas

30   820 of the beam 800 can be provided between the melting level and the crystallization threshold. Thus, when the beam 800 irradiates particular portions of the

semiconductor thin film which is then crystallized, such portions would likely have an edge regions in thus irradiated and crystallized areas of the semiconductor thin film that are likely to have large non-uniform edge regions spatially corresponding to the portions 830 of the beam 800. The edge regions are known to be disadvantageous for placing the TFT devices (and especially their active regions) thereon.

Attempts have been made to eliminate the edge effect (i.e., non-uniformity of the edge areas) of the irradiated and crystallized portions of the semiconductor film. U.S. Patent No. 5,591,668 issued to Maegawa et al. tries to minimize these edge areas by using a substantially square shaped beams (rotated 45° and having rounded peaks) that sequentially overlap one another using a laser annealing method. However, such conventional procedure would require multiple irradiation by the beam pulses of the same areas, and the processing of the semiconductor film would be somewhat slow.

Accordingly, it is preferable to irradiate and crystallize at least some of the areas of the semiconductor films by passing the beam pulses through a mask in a way so as to eliminate the problem caused by such edge effect by clearly defining the profile of the beam pulse. It is preferable to significantly reduce the spatial scale associated with the edge region so as to make it possible to have such regions be provided away from the active regions of the TFT devices. In addition, multiple irradiations of the same area on the semiconductor film would therefore no longer be necessary.

SUMMARY OF THE INVENTION

Therefore, one of the objects of the present invention is to provide an improved process and system which can make the edge regions of the crystallized areas of the semiconductor thin film relatively small (e.g., one such region can be smaller than the distance between the adjacent TFT devices). Thus, it is possible to place the active regions of the TFT devices on the semiconductor thin film away from these edge regions. Another object of the present invention is to increase the speed to process the semiconductor films for their use with the liquid crystal displays and/or organic light emitting diode displays. Still another object of the present is to have a

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capability for utilizing various fluences of the beam pulse for irradiating the areas of the semiconductor thin film, so long as such fluence induces a crystallization of the irradiated areas of the semiconductor thin film.

In accordance with at least some of these objectives as well as others
5   that will become apparent with reference to the following specification, it has now been determined that the reduction the size of the edge regions of the irradiated and crystallized areas of the semiconductor thin film is advantageous to reduce the edge effect. It was also ascertained that the grains provided in the edge regions of such areas are different from the grains of the areas that are arrangement, e.g., between two
10   oppositely-spaced edge regions of the semiconductor thin film. Further, it was determined that the use of the two-dimensional mask to pass the beam pulse there through configured the profile of the resultant masked beam pulse to be well defined, thus decreasing or eliminating the portion of the beam pulse which may have a gradually-reducing fluence level that may cause the undesired edge effect.

15   In one exemplary embodiment of the present invention, a process and system for processing a semiconductor thin film sample are provided. In particular, a beam generator can be controlled to emit at least one beam pulse. The beam pulse is then masked to produce at least one masked beam pulse, which is used to irradiate at least one portion of the semiconductor thin film sample. With the at least one masked
20   beam pulse, the portion of the film sample is irradiated with sufficient intensity for such portion to later crystallize. This portion of the film sample is allowed to crystallize so as to be composed of a first area and a second area. Upon the crystallization thereof, the first area includes a first set of grains, and the second area includes a second set of grains whose at least one characteristic is different from at
25   least one characteristic of the second set of grains. The first area surrounds the second area, and is configured to allow an active region of a thin-film transistor ("TFT") to be provided at a distance therefrom.

In another embodiment of the present invention, the masked beam pulse can have the intensity sufficient to completely melt the irradiated portion of the
30   semiconductor thin film sample throughout its thickness (or partially melt such

portion). The active region of the TFT can be situated within the second area. The second area may correspond to at least one pixel. The second area has a cross-section for facilitating thereon all portions of the TFT. A size and a position of the first area with respect to the second area are provided such that the first area provides either no

5   effect or a negligible effect on a performance of the TFT.

According to still another embodiment of the present invention, a location of the first area can be determined so as to avoid a placement of the active region of the TFT thereon. The beam pulse may include a plurality of beamlets, and the first and second areas can be irradiated by the beamlets. The semiconductor thin

10   film sample may be a silicon the film sample. The semiconductor thin can be composed of at least one of silicon and germanium, and may have a thickness approximately between 100Å and 10,000Å. The first set of grains provided in the first area may be laterally-grown grains.

According yet another embodiment of the present invention, a

15   semiconductor thin film sample includes at least one section irradiated by at least one masked beam pulse which is configured to irradiate the at least one section of the sample for a later crystallization thereof. The irradiated portion of the film sample is crystallized to include a first area and a second area. Upon the crystallization thereof, the first area includes a first set of grains, and the second area includes a second set of

20   grains whose at least one characteristic is different from at least one characteristic of the second set of grains. The first area surrounds the second area, and is configured to allow an active region of a thin-film transistor ("TFT") to be provided at a distance therefrom.

25   The accompanying drawings, which are incorporated and constitute part of this disclosure, illustrate a preferred embodiment of the invention and serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a schematic block diagram of an exemplary embodiment of an irradiation system according to the present invention which irradiates particular areas of a semiconductor thin film of a sample such that these areas have a relatively small edge regions;

5   Fig. 1B is an enlarged cross-sectional side view of the sample which includes the semiconductor thin film;

Fig. 2 is a top exploded view of an exemplary embodiment of the sample conceptually subdivided, and having a semiconductor thin film thereon on which a process according to the present invention is performed for the entire surface

10   area a semiconductor thin film using the exemplary system of Fig. 1A;

Fig. 3 is a top view of a first exemplary embodiment of a mask according to the present invention which has a beam-blocking area surrounding one open or transparent area, and which can be used with the exemplary system of Fig. 1A to mask the beam pulses generated by a laser beam source into a patterned beam

15   pulse, such that such masked beam pulses irradiate the particular areas on the semiconductor film thereby reducing the edge regions provided at the peripheries of such areas;

Figs. 4A-4D are irradiations, by the radiation beam pulse which is masked by the mask of Fig. 3, and then re-solidifications and crystallizations of the

20   particular portions of the semiconductor film provided on the sample for an first exemplary conceptual column of the sample at various sequential stages of the exemplary embodiment according to the process of the present invention in which the edge regions of the particular portions are significantly reduced;

Figs. 4E-4F are irradiations, by the radiation beam pulse which is

25   masked by the mask of Fig. 3, and then re-solidifications and crystallizations of the particular portions of the semiconductor film provided on the sample for an second exemplary conceptual column of the sample at two exemplary sequential stages of the processing according to the process of the present invention, which continue from the first conceptual column of Figs. 4A-4D;

Fig. 5A is a top view of a second exemplary embodiment of the mask according to the present invention which has a beam-blocking area surrounding multiple small open or transparent areas or slits, and which can be used with the exemplary system of Fig. 1A to mask the beam pulses generated by a beam source

5   into patterned beamlets, such that such masked beamlet pulses irradiate the particular areas on the semiconductor film whose edge regions are significantly reduced;

Fig. 5B is an enlarged view of the beamlets of the second embodiment of the mask illustrated in Fig. 5A;

Figs. 6A-6D are irradiations, by the radiation beam pulse intensity

10   pattern which is masked by the mask of Fig. 5, and then re-solidifications and crystallizations of the particular portions of the semiconductor film provided on the sample for the first conceptual column of the sample at various sequential stages of the first exemplary embodiment of the exemplary embodiment according to the process of the present invention;

15   Fig. 7 is an illustration of the semiconductor thin film provided on the sample, and such thin film being irradiated by the beam pulse having a cross-section that is patterned by a mask having a beam-blocking area surrounding one long and narrow open or transparent area, and which can be used with the exemplary system of Fig. 1A;

20   Fig. 8A is an illustration of the two particular areas irradiated, re-solidified and crystallized areas corresponding to the areas of Figs. 4D and 6D in which the edge regions of each of these areas are provided away from the entire TFT device;

Fig. 8B is an illustration of the two particular areas irradiated, re-

25   solidified and crystallized areas corresponding to the areas of Figs. 4D and 6D in which the edge regions of these two areas are provided away from the entire cross-section of the active region of the TFT device, while other regions are provided on such edge regions;

Fig. 9 is a flow diagram representing an exemplary processing

30   procedure of the present invention under at least partial control of a computing

arrangement of Fig. 1A using the exemplary techniques of the present invention of Figs. 4A-4F and 6A-6D;

Fig. 10 is a flow diagram representing another exemplary processing procedure of the present invention under at least partial control of a computing
5   arrangement of Fig. 1A using the exemplary techniques of the present invention of Figs. 4A-4F and 6A-6D, and in which the beam source of Fig. 1A is triggered based on the positions of the semiconductor film with respect to the impingement of the beam;

Fig. 11A is a perspective cut-away view of a profile of a long and
10   narrow beam which is shaped by a projection irradiation using conventional systems and processes;

Fig. 11B is a graph of the fluence of the beam of Fig. 11A against the spatial profile of the beam generated by the conventional systems and processes; and

Fig. 12 is a exemplary graph of the fluence of the beam against the
15   spatial profile of the beam generated by the system and process according to the present invention which reduces the edge regions of the particular portions of the semiconductor thin film irradiated by such beam.

DETAILED DESCRIPTION

It should be understood that various systems according to the present
20   invention can be utilized to mask, irradiate and crystallize one or more portions on the semiconductor (e.g., silicon) film so as to reduce edge areas of these portions and to place at least an active region of a thin-film transistor ("TFT") away from the edge regions of such portions.   The exemplary embodiments of the systems and process to achieve such areas as well as of the resulting crystallized semiconductor thin films
25   shall be described in further detail below. However, it should be understood that the present invention is in no way limited to the exemplary embodiments of the systems processes and semiconductor thin films described herein.

In particular, Fig. 1A shows a system according to the present invention which is used on a sample 170 which has an amorphous silicon thin film

thereof that is being irradiated by masked irradiation beam pulses to promote the masked irradiation, solidification and crystallization of the particular areas of the semiconductor thin film in which the edge regions are minimized. The exemplary system includes a beam source 110 (e.g., a Lambda Physik model LPX-315I XeCl

5 pulsed excimer laser) emitting an irradiation beam (e.g., a laser beam), a controllable beam energy density modulator 120 for modifying the energy density of the laser beam, a MicroLas two plate variable attenuator 130, beam steering mirrors 140, 143, 147, 160 and 162, beam expanding and collimating lenses 141 and 142, a beam homogenizer 144, a condenser lens 145, a field lens 148, a projection mask 150 which

10 may be mounted in a translating stage (not shown), a 4×-6× eye piece 161, a controllable shutter 152, a multi-element objective lens 163 for focusing a radiation beam pulse 164 onto the sample 170 having the semiconductor thin film to be processed mounted on a sample translation stage 180, a granite block optical bench 190 supported on a vibration isolation and self-leveling system 191, 192, 193 and 194,

15 and a computing arrangement 100 (e.g., a general purpose computer executing a program according to the present invention or a special-purpose computer) coupled to control the beam source 110, the beam energy density modulator 120, the variable attenuator 130, the shutter 152 and the sample translation stage 180.

The sample translation stage 180 is preferably controlled by the

20 computing arrangement 100 to effectuate translations of the sample 170 in the planar X-Y directions, as well as in the Z direction. In this manner, the computing arrangement 100 controls the relative position of the sample 40 with respect to the irradiation beam pulse 164. The repetition and the energy density of the irradiation beam pulse 164 are also controlled by the computer 100. It should be understood by

25 those skilled in the art that instead of the beam source 110 (e.g., the pulsed excimer laser), the irradiation beam pulse can be generated by another known source of short energy pulses suitable for completely melting throughout their entire thickness selected areas of the semiconductor (e.g., silicon) thin film of the sample 170 in the manner described herein below. Such known source can be a pulsed solid state laser,

30 a chopped continuous wave laser, a pulsed electron beam and a pulsed ion beam, etc. Typically, the radiation beam pulses generated by the beam source 110 provide a

beam intensity in the range of 10 mJ/cm^2 to 1J/cm^2 (e.g., 500mJ/cm^2) a pulse duration (FWHM) in the range of 10 to 103 nsec, and a pulse repetition rate in the range of 10 Hz to 104 Hz.

5   While the computing arrangement 100, in the exemplary embodiment of the system shown in Fig. 1A, controls translations of the sample 170 via the sample stage 180 for carrying out the processing of the semiconductor thin film of the sample 170 according to the present invention, the computing arrangement 100 may also be adapted to control the translations of the mask 150 and/or the beam source 110 mounted in an appropriate mask/laser beam translation stage (not shown for the

10   simplicity of the depiction) to shift the intensity pattern of the irradiation beam pulses 164, with respect to the semiconductor thin film of the sample 170, along a controlled beam path. Another possible way to shift the intensity pattern of the irradiation beam pulse is to have the computer 100 control a beam steering mirror. The exemplary system of Fig. 1 may be used to carry out the processing of the silicon thin film of the

15   sample 170 in the manner described below in further detail. It should also be understood that it is possible to exclude the mask 150 from the system according to the present invention. Without such mask 150, the beam source 11 0, the energy density modulator, the beam attenuator and/or other components of the system of the present invention can be used to shape the beam 149 so as to impinge and irradiate

20   selected portions of the semiconductor thin film of the sample 170.

As illustrated in Fig. 1B, the semiconductor thin film 175 of the sample 170 can be directly situated on e.g., a glass substrate 172, and may be provided on one or more intermediate layers 177 there between. The semiconductor thin film 175 can have a thickness between 100Å and 10,000Å (1μm) so long as at least certain

25   necessary areas thereof can be completely melted throughout their entire thickness. According to an exemplary embodiment of the present invention, the semiconductor thin film 175 can be composed of silicon, germanium, silicon germanium (SeGe) all of which preferably having low levels of impurities. It is also possible to utilize other elements or semiconductor materials for the semiconductor thin film 175. The

30   intermediary layer 177, which is situated immediately underneath the semiconductor thin film 175, can be composed of silicon oxide (SiO$_2$), silicon nitride (Si$_3$N$_4$), and/or

mixtures of oxide, nitride or other materials that are suitable for promoting nucleation and small grain growth within the designated areas of the semiconductor thin film 175 of the sample 170. The temperature of the glass substrate 172 can be between room temperature and 800°C. Higher temperatures of the glass substrate 172 can be
5   accomplished by preheating the substrate 172 which would effectively allow larger grains to be grown in the nucleated, re-solidified, and then crystallized areas of the semiconductor thin film 175 of the sample 170 due to the proximity of the glass substrate 172 to the thin film 175.

Fig. 2 shows an enlarged view of an exemplary embodiment of the
10   semiconductor thin film 175 (e.g., an amorphous silicon thin film) of the sample 170, and the relative translation paths of the beam pulse 164 with respect to the locations on the sample 170. This exemplary sample 170 has exemplary dimensions of 40 cm in the Y direction by 30 cm in the X direction. The sample 170 can be conceptually subdivided into a number of columns (e.g., a first conceptual column 205, a second
15   conceptual column 206, a third conceptual column 207, etc.). The location/size of each conceptual column may be stored in a storage device of the computing arrangement 100, and utilized by the computing 100 for later controlling the translation of the sample 170, and/or firing of the beam in by the beam source 110 at such relative locations of the semiconductor thin film 175, or on other locations that
20   are based on the stored locations. Each of the conceptual columns 205, 206, 207, etc. is dimensioned, e.g., ½ cm in the Y direction by 30 cm in the X direction. Thus, if the sample 170 is sized 40 cm in the Y direction, the sample 150 may be conceptually subdivided into eighty (80) columns. The sample 170 may also be conceptually subdivided into such columns having other dimensions (e.g., 1 cm by 30 cm columns,
25   2 cm by 30 cm columns, 2 cm by 30 cm columns, etc.). In fact, there is absolutely no restrictions on the dimensions of the conceptual columns of the sample 170 so long as the masked beam pulse 164 is capable of irradiating certain areas of the semiconductor thin film 175 in such columns to promote crystallization within such areas.

30   In particular, according to the present invention, it is important to provide relatively small edges region at the peripheries of these areas of the film

sample 175 so as to allow at least the active region of the TFT device to be placed away from these very small edge regions. The small size of the edge regions is primarily due to the use of the mask 150 to generate a sharp profile of the beam 111 as the masked beam pulse 164 The location/dimension of each conceptual column,

5　　and the locations thereof, are stored in the storage device of the computing arrangement 100, and utilized by such computing arrangement 100 for controlling the translation of the translation stage 180 with respect to the beam pulse 164 and/or the firing of the beam 111 by the beam source 110 at those locations of the semiconductor thin film sample, or on other locations.

10　　　　　　For example, the semiconductor thin film 175 can be irradiated by the beam pulse 164 whose profile is defined using the mask 150 according to a first exemplary embodiment of the present invention as shown in Fig. 3. The first exemplary mask 150 is sized such that its cross-sectional area is larger than that of the cross-sectional area of the masked beam pulse 164. In this manner, the mask 150 can

15　　pattern the pulsed beam to have a shape and profile directed by the open or transparent regions of the mask 150. This can be commonly referred to as a "two-dimensional projection", which generally the shape of the beam, and reduces such shape in all directions. Such projection is significantly different from a single axis projection which does not utilize a mask, and merely shapes and reduces the beam in

20　　one direction. Fig. 12 show a preferable profile 850 of the masked beam pulse 164 as the pulse 149 is passed through the mask 150. This profile 850 is well defined so as to minimize the edge regions provided at the peripheries of the irradiated portions of the semiconductor thin film 175.

　　　　　　In this exemplary embodiment shown in Fig. 3, the mask 150 includes

25　　a beam-blocking section 155 and an open or transparent section 157. The beam-blocking section 155 prevents those areas of the pulsed beam impinging such section 155 from being irradiated there-through, thus preventing the further entering the optics of the exemplary system of the present invention shown in Fig. 1A to irradiate the corresponding areas of the semiconductor thin film 175 provided on the sample

30　　170. In contrast, the open or transparent section 157 allows the portion of the beam pulse 164 whose cross-section corresponds to that of the section 157 to enter the

optics of the system according to the present invention, and irradiate the corresponding areas of the semiconductor thin film 175. In this manner, the mask 150 is capable of patterning the beam pulse 164 so as to impinge the semiconductor thin film 175 of the sample 170 at predetermined portions thereof as shall be described in

5   further detail below.

According to the present invention, the masked beam pulse 164 can have various energy fluences. For example, such fluence of the masked beam pulse 164 can small, but which promotes an explosive crystallization. The fluence of the beam pulse 164 can be higher than the small fluence to promote partial melting of the

10   irradiated portions of the semiconductor thin film 175, and then crystallization of such portions. In addition, the fluence can be higher than the fluence promoting partial melting so as to allow a near-complete melting of the portions of the semiconductor thin film 175. Furthermore, the fluence of the masked beam pulse 164 can be high enough to completely melt the above-described irradiated portions of the thin film

15   175. In summary, the fluence should be large enough to allow the portions of the semiconductor thin film 175 to crystallize after being irradiated by the masked beam pulse 164.

A first exemplary embodiment of the process according to the present invention shall now be described with reference to the irradiation of the

20   semiconductor thin film 175 of the sample 170 as illustrated in Figs. 4A-4F. In this exemplary process of the present invention, the beam pulse 149 is shaped by the exemplary mask 150 of Fig. 3, and the exemplary irradiation and/or impingement of the semiconductor thin film 175 of the sample 170 is shown in Fig. 2. For example, the sample 170 may be translated with respect to the beam pulse 164, either by

25   moving the mask 150 or the sample translation stage 180, in order to irradiate selective areas of the semiconductor thin film 175 of the sample 170. For the purposes of the foregoing, the length and width of the laser beam 149 may be greater than 1 cm in the X-direction by ½ cm in the Y-direction (e.g., a rectangular shape) so that it can be shaped by the mask 150 of Fig. 3. However, it should be understood the

30   pulsed laser beam 149 is not limited to such shape and size. Indeed, other shapes

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and/or sizes of the laser beam 149 are, of course, achievable as is known to those having ordinary skill in the art (e.g., shapes of a square, triangle, circle, etc.).

After the sample 170 is conceptually subdivided into columns 205, 206, 207, etc., a pulsed laser beam 111 is activated (by actuating the beam source 110
5   using the computing device 100 or by opening the shutter 130), and produces the pulsed laser beamlets 164 which impinges on a first location 220 which is away from the semiconductor thin film 175. Then, the sample 170 is translated and accelerated in the forward X direction under the control of the computing arrangement 100 to reach a predetermined velocity with respect to the fixed position beamlets in a first
10   beam path 225.

In one exemplary variation of the process of the present invention, the pulsed beamlets 164 can reach a first edge 210' of the sample 170 preferably when the velocity of the movement of the sample 170 with respect to the pulsed laser beam 149 reaches the predetermined velocity. Then, the sample 170 is continuously (i.e.,
15   without stopping) translated in the -X direction at the predetermined velocity so that the pulsed beamlets 164 continue irradiating successive portions of the sample 170 for an entire length of a second beam path 230.

After passing the first edge 210', the beam pulse 164 impinges and irradiates a first area 310 of the semiconductor thin film 175, preferably with enough
20   intensity to irradiate such area so that the crystallization thereof is then promoted, as illustrated in Fig. 4A. The fluence of the masked beam pulse 164 should preferably be large enough to promote crystallization of the irradiated portions of the semiconductor thin film 175. Then, as shown in Fig. 4B, this first area 310 is allowed to crystallize, thereby forming two regions therein – a first center region 315 and a first minimized
25   edge region 318. The first center region 315 is formed after the irradiation of the first area 310 by the masked beam pulse 164. The dimensions of this center region 315 are slightly smaller that the dimensions of the masked beam pulse 164 irradiating the first area 310, with the first center region 315 being surrounded by the first edge region 318 (the details of which are described herein below). Again, the size of the first edge
30   region 318 is minimized due to the masking of the beam pulse 149 to become the

masked beam pulse 164 which preferably has the profile 850 illustrated in Fig. 12. It should be note that the characteristics of the grains (e.g., length, orientation, etc.) of the first center area 315 and the characteristics of the first edge area 318 are different; such differences is one of the main reasons for the reduction of the edge regions.

5   The first edge region 318 can formed by laterally growing the grains from the borders between the unirradiated portions of the semiconductor thin film 175 and the first irradiated area 310. This is the case when the masked beam pulse 164 has the fluence to completely melt the first area 310. The grains in the first center region 318 grown from these borders toward the center of the first melted area for a

10   predetermined small distance, to reach the first center region 315, and form a border there between. Of course, it should be understood that if the masked beam pulse 164 does not have enough intensity to completely melt the first area, grains are formed in the first edge region in any event. Generally, the grains of the first center region 315 are larger than those in the first edge region 318. This is preferably because the

15   intensity of the masked beam pulse 164 is greater in the center thereof than at the edges. The predetermined distance is small because the beam pulse 149 is irradiated through the mask 149 to form the masked beam pulse 164 which does not have large gradually decreasing edge portions (e.g., portions 820 of the conventional beam pulse 800 as shown in Figs. 11A and 11B), and in fact preferable has the intensity pattern

20   850 illustrated in Fig. 12. For example, the predetermined distance can be 1 μm, while the width of the first center region may be slightly less than 1 cm.. Therefore, the first edge region 318 is significantly smaller that the first center region 315 which it surrounds. For the purposes of the present invention, it is undesirable to position the active regions of the TFT devices on such edge regions, so that the active regions (and

25   possibly the entire TFT devices) are placed away from these edge regions.

        Thereafter, as shown in Fig. 4C, the sample 170 is continued to be translated (or the mask 150 is configured to be adjusted) such that the beam pulse 164 irradiates a second area 320 of the semiconductor thin film 175 in the manner discussed herein above for the first area 310. This second area 320 which can be a

30   subsequent area immediately following the first area 320 in the first conceptual column 205 along the +X direction.

Similarly to the first area 310, the second area 320 crystallizes into a second center region 325 and a second edge region 328, which correspond to the characteristics and dimensions of the first center region 31 5 and the first edge region 318, respectively. If, during the irradiation of the second area 320 (and in an exemplary case of complete melting thereof), the masked beam pulse 164 slightly overlaps the first edge region 318, then upon crystallization, the grains in this region 318 seed and laterally grow a portion of the completed melted second area 320 which is immediately adjacent to the first edge region 318. In this manner, the adjacent section of the second edge region 328 is seeded by the first laterally-grown region 318 to laterally grow grains therefrom. Nevertheless, the second edge region 328 is still very small (e.g., 1μm) as compared to the second center area 325. The resultant crystallized second area 320 is illustrated in Fig. 4D. It is also within the scope of the present invention for the second area 320 to be provided at a distance from the crystallized first area 310. In this manner and in case of the complete melting of the second area 320, the sections of the second edge region 32 8 which is situated closest to the crystallized first laterally-grown region 318 can be seeded by the grains from an un-irradiated section between the first area 310 and the second area.

The first edge area 318 and/or the second edge area 328 are preferably sized such that the cross-sectional area thereof is smaller that the distance between the TFT device (especially the active regions thereof) which is situated in the first center region 31S and the TFT device situated in the second center region 325.

The translation and irradiation of the first conceptual column 205 of the semiconductor thin film 175 continues until all areas 310, 320, ..., 380, 390 (and their respective center regions 315, 325, ..., 385, 395 and edge regions 318, 328, ..., 388, 398) in this first conceptual column 205 is continued until the pulsed beamlets 164 reach a second edge 210" of the sample 170, as illustrated in Fig. 4E. The crystallization of the areas 310, 320, ..., 380, 390 along the first conceptual column 205 is performed in a substantially repetitive manner. When the beam pulse 164 passes the second edge 210", the translation of the sample 170 may be slowed with respect to the masked beam pulse 164 (in a third beam path 235) to reach a second location 240 (see Fig. 2). It should be noted that it is not necessary to shut down the

pulsed beam 111 after the masked beam pulse 164 has crossed the second edge 210" of the sample 170 because it is no longer irradiating the sample 170.

While being away from the sample 170 and the second edge 210", the sample is translated in a -Y direction to a third location 247 via a fourth beam path

5   245 so as to be able to irradiate the sections of the semiconductor thin film 175 along the second conceptual column 206. Then, the sample 170 is allowed to settle at that location 247 to allow any vibrations of the sample 170 that may have occurred when the sample 170 was translated to the third location 247 to cease. Indeed, for the sample 170 to reach the second conceptual column 206, it is translated approximately

10   ½ cm for the columns having a width (in the -Y direction) of ½ cm. The sample 170 is then accelerated to the predetermined velocity via a fourth beam path 250 in the –X direction so that the impingement of the semiconductor thin film 175 by the beam pulse 164 reaches, and then bypasses the second edge 210".

Thereafter, the sample 170 is translated along a fifth beam path 255,

15   and the exemplary process described above with respect to the irradiation of the first column 205 may then be repeated for the second conceptual column 206 to irradiate further areas 410, 420, and their respective center regions 415, 425 and edge regions 418, 428 while translating the sample in the +X direction. In this manner, all conceptual columns of the sample 170 can be properly irradiated. Again, when the

20   beam pulse 164 reaches the first edge 210', the translation of the sample 170 is decelerated along a sixth beam path 260 to reach a fourth location 265. At that point, the sample 170 is translated in the –Y direction along the seven beam path 270 for the beam pulse to be outside the periphery of the sample 170 to reach fifth location 272, and the translation of the sample 170 is allowed to be stopped so as to remove any

25   vibrations from the sample 170. Thereafter, the sample 170 is accelerated along the eighth beam path 275 in the –X direction so that the beam pulse 164 reaches and passes the first edge 210' of the sample 170, and the beam pulse 164 irradiates (e.g., to partially or completely melt) certain areas in the third conceptual column 207 so that they can crystallize in substantially the same manner as described above for the areas

30   310, 320, ..., 380, 390 of the first conceptual column 205 and the areas 410, 420, ... of the second conceptual column 206.

18

This procedure may be repeated for all conceptual columns of the semiconductor thin film 175, for selective columns of particular sections of the thin film 175 which are not necessarily conceptually subdivided into columns. In addition, it is possible for the computing arrangement 100 to control the firing of the beam 111

5 by the beam source 110 based on the predefined location stored in the storage device of the computing arrangement 100 (e.g., instead of irradiating the semiconductor thin film 175 by setting predetermined time period between the beam pulses or setting pulse durations). For example, the computing arrangement 100 can control the beams source 110 to generate the beam 111 and irradiate only at the predetermined locations

10 of certain areas of the thin film 175 with its corresponding beam pulse 164, such that these locations are stored and used by the computing arrangement 100 to initiate the firing of the beam 111 which results in the irradiation by the beam pulse only when the sample 170 is translated to situate those areas directly in the path of the beam pulse 164. The beam source 110 can be fired via the computing arrangement 100

15 based on the coordinates of the location in the X direction.

In addition, it is possible to translate the sample 170 in a manner which is not necessary continuous, when the path of the irradiation of the beam pulse 164 points to the areas on the semiconductor thin film 175 to be melted and crystallized. Thus, it is possible for the translation of the sample 170 to be stopped in the middle of

20 the sample 170, with the area in the middle being irradiated and then crystallized. Thereafter, the sample 170 can be translated so that another section of the semiconductor thin film 175 is arranged in the path of the beam pulse 164, such that the translation of the sample is then stopped again and the particular section is irradiated and completely melted in accordance with the exemplary embodiment of

25 the process described in great detail above, as well as the embodiments of the process which shall be described below.

According to the present invention, any mask described and shown herein and those described and illustrated in U.S. patent application serial no. 09/390,535, the entire disclosure of which is incorporated herein by reference, may be

30 used for the process and system according to the present invention. For example, instead of using the mask shown in Fig. 3 which allows the semiconductor thin film

175 to be flood-irradiated, a second exemplary embodiment of the mask 150'
illustrated in Fig. 5A can be utilized. In contrast to the mask 150 of Fig. 3 which has
a single open or transparent region 157, the mask 150' has multiple open or
transparent regions 450 which are separated from one another by beam-blocking

5   regions 455. The open or transparent regions 450 of the mask 150' can also be
referred to as "slits." These slits permit small beam pulses (or beamlets) to irradiate
there-through and completely melt the areas of the semiconductor thin film 175 that
they impinge. An enlarged illustration of one of the slits 450 is provided in Fig. 5B,
which shows that the dimensions of the slits 450 can be 0.5 μm by 0.5 μm. It should

10   be clearly understood that other dimensions of the slits are possible, and are within the
scope of the present invention. For example, the slits can have a rectangular shape, a
circular shape, a triangular shape, a chevron shape, a diamond-shaped shape, etc.
According to the present invention, the slits should be sufficiently large so that when
the pulsed beamlets 164 formed thereby irradiate and crystallize the particular areas of

15   the semiconductor thin film 175, the center portions (i.e., not the edge regions) are
formed so as to situate the TFT devices (or at least their active regions) therein. It is
important that the active regions of such situated TFT devices have respective
distances from one another which are greater that the edge regions of the beamlet-
irradiated and crystallized areas.

20   Figs. 6A-6D show an exemplary progression of a second embodiment
of the process according to the present invention in which a plurality of successive
areas along the first conceptual column 205 of the semiconductor thin film 175 is
irradiated by the masked beam pulse 164 (comprised of beamlets) which is shaped by
the mask 150' of Fig. 5A. The translation of the sample 170 with respect to the

25   impingement thereof by the beam pulse 164 is substantially the same as the
translation described above with reference to Figs. 4A-4F. The difference between
the irradiation of the areas 310, 320, ..., 380, 390, 410, 420 by the beam pulse 164
shaped by the mask 150 of Fig. 3 and the areas 460, 470 by the beam pulse 164
shaped by the mask 150' is that substantially the entire areas 310, 320, ... , 380, 390,

30   410, 420 are irradiated and crystallized, as opposed to only certain small portions 462
of the areas 460, 470 are irradiated and crystallized.

Similarly to the area 3 10 in Fig. 4A, the portions 462 of the area 460 are irradiated as illustrated in Fig. 6A. Thereafter, the portions 462 are crystallized to form the center regions 465, and the edge regions 468 as shown in Fig. 4B. Similarly to the first center regions 315, the center regions 465 of the respective portions 462

5 have grains therein which are different than the grains of the edge regions 468, and are sized such that at least an active region of the TFT device (and possible the entire TFT device) can be placed away from the edge regions 468. As shown in Fig. 6C, upon the translation of the sample 170 in the –X direction, portions 472 of the area 470 are irradiated and then crystallized in a substantially the same manner as the

10 portions 462. Therefore, the center regions 475 and the edge regions 478 of the area 470 are formed.

In addition, it is possible to utilize a third embodiment of a mask 150" according to the present invention as shown in Fig. 7 which has a long and narrow open or transparent region 490 so as to pattern and shape the beam 149 into the beam

15 pulse 164. For example, the length of the region 490 can be 0. 5 cm and the width thereof may be 0.1 mm. In this manner, each conceptual column of the sample 170 illustrated in Fig. 2 can be irradiated by the beam pulse 164 shaped by this mask 150". In addition, it may be possible for the length of the region 490 to be 30 cm. Thus, instead of subdividing the semiconductor thin film 175 into a number of conceptual

20 columns, and irradiating each column separately, it is possible to irradiate and crystallize selected portions of the semiconductor thin film 175 by translating the sample 170 in the –Y direction from one edge of the sample 170 to the opposite edge thereof. It is important that the center regions be formed using such processing technique such that it would be possible to keep the active regions of the respective

25 TFT devices at a distance from the edge regions.

Fig. 8A shows an illustration of the first and second irradiated and crystallized areas 510 and 520 possibly corresponding to the first and second areas 310, 320 of Figs. 4D and/or the adjacent portions 462 of the area 460 of Fig. 6D. In particular, Fig. 8A shows that the entire TFT devices 610 and 620 can be situated

30 away from the edge regions 518, 528, 650, and possibly within the respective center regions 515, 525 of the areas 510, 520. The first TFT device 6 10 situated in the

center region 515 of the area 510 includes a gate 612, a drain 614, a source 616 and an active region 618, all of which are situated away from the edge region 518. Similarly, for the second TFT device 610, its gate 622, drain 624, source 626, and especially active region 628 are also situated away from the edge regions 528, 650 such that they
5   do not overlap the respective edge region 528 of the area 520, and the edge region 650 which is provided between the center regions 515, 525.

Fig. 8B shows an illustration of the first and second irradiated and crystallized areas 510 and 520 also possibly corresponding to the adjacent portions 462 of the area 460 of Fig. 6D with the respective TFT devices 610, 620' provided
10 thereon. In this exemplary embodiment, only respective active regions 618', 628' of the areas 510, 520 are provided away from the edge regions 518, 528, 650, and are provided within the respective uniform center regions 515, 525 of the areas 510, 520, while other portions of the TFT devices 610', 620' are situated on the respective edge regions 518, 528 of the areas 510, 520, and the edge area provided there between. In
15 particular, the first TFT device 610' includes an active region 618' which entirely situated in the center region 515 of the area 510, while a gate 612', a drain 614' and a source 616' of the TFT device 610' overlap the edge region 518. Similarly, for the second TFT device 610', an active region 628' thereof is entirely situated within the respective center region 525 of the area 520, while a gate 622', a drain 624' and a
20 source 626 of the second TFT device 620' are provided directly on the respective edge regions 528 of the area 520. Also, the gate 622' is provided on a border region 500 (i.e., the edge region 650 between the areas 510, 520) between the center region 515 of the area 510 and the center region 525 of the area 520. It should be understood that any one of the gate 612, 612', 622, 622' drain 614, 614', 624, 624' and source 616,
25 616', 626, 626' can be provided on the edge regions 518, 528 and the border region 500.

By using this exemplary embodiment of the present invention, the edge region 500 and/or the width of the edge regions 518, 528 associated with such edge region 500 can be reduced to 1 μm, which is approximately 100 to 10,000 smaller than
30 the edge regions obtained using the conventional systems and process. Therefore, it would be possible to achieve the placement of the entire TFT device 610, 620 in the

center regions 515, 525 such that the distance between which would be greater that
the edge region 500, as illustrated in Fig. 8A. Similar applies for the placement of the
TFT devices 610', 620' as shown in Fig. 8B, except that the distance between the
active regions 618', 628' of the respective TFT devices 610', 620' would be greater
5   than the width of the edge region 500.

Fig. 9 is a flow diagram representing a first exemplary processing
procedure of the present invention under at least a partial control of a computing
arrangement of Fig. 1A using the techniques of the present invention of Figs. 4A-4F
and 6A-6D. In step 1000, the hardware components of the system of Fig. 1A, such as
10   the beam source 110, the energy beam modulator 120, and the beam attenuator and
shutter 130 are first initialized at least in part by the computing arrangement 100. The
sample 170 is loaded onto the sample translation stage 1800 in step 1005. It should
be noted that such loading may be performed either manually or automatically using
known sample loading apparatus under the control of the computing arrangement 100.
15   Next, the sample translation stage 180 is moved, preferably under the control of the
computing arrangement 100, to an initial position in step 1010. Various other optical
components of the system are adjusted and/or aligned either manually or under the
control of the computing arrangement 100 for a proper focus and alignment in step
1015, if necessary. In step 1020, the irradiation/laser beam 111 is stabilized at a
20   predetermined pulse energy level, pulse duration and repetition rate. In step 1024, it
is preferably determined whether each beam pulse has sufficient energy to irradiate
the portions of the semiconductor thin film so as to crystallize such portions
thereafter. If that is not the case, the attenuation of the beam 111 is adjusted by the
beams source 110 under the control of the computing arrangement 100 in step 1025,
25   and step 1024 is executed again to determine if the there is sufficient energy to
crystallize the portions of the semiconductor thin film.

In step 1027, the sample is positioned to point the beam pulse 164 to
impinge the first column of the semiconductor thin film. Then, in step 1030, the
portions of the semiconductor thin film are irradiated using a masked intensity pattern
30   (e.g., the masked beam pulse 164). Thereafter, the irradiated portions of the
semiconductor thin film are crystallized with the minimized edge regions therein so as

to allow at least the active regions of the TFT devices to be placed away from such edge regions. In step 1035, it is determined whether the irradiation for the current column by the beam pulse has been completed. If no, in step 1040, the sample is continued to be irradiated with the next beam pulse 164. However, if in step 1035, it

5　is determined that the irradiation and crystallization of the current column is completed, then it is determined in step 1040 whether there are any further columns of the sample to be processed. If so, the process continues to step 1050 in which the sample is translated to that the beam pulse is pointed to the next column to be processed according to the present invention. Otherwise, in step 1055, the exemplary

10　processing has been completed for the sample 170, and the hardware components and the beam 111 of the system shown in Fig. 1A can be shut off, along with the process terminating.

Fig. 10 is a flow diagram representing a second exemplary processing procedure of the present invention under at least a partial control of a computing

15　arrangement of Fig. 1A using the techniques of the present invention of Figs. 4A-4F and 6A-6D, in which is preferable to mask the beam 111. Steps 1100-1120 of this exemplary procedure are substantially the same as the steps 1000-1020 of the procedure of Fig. 9 and thus shall not be described herein in further detail. In step 1024, however, it is determined whether each pulse has enough energy to irradiate at

20　least portions of the semiconductor thin film 175 such that the irradiated portion crystallize. If not, in step 1125, the attenuation for the beam pulse is adjusted, and the energy fluence is verified again. Upon the verification of the energy fluence of the beam pulse, the sample is moved to impinge a first column of the sample 170.

Then, in step 1130, the resultant beam 149 is passed through a mask

25　159 to shape the beam pulse, and shape the edge portions of the resultant pulse. Then, the sample 170 is continuously translated along the current column in step 1135, In step 1140, during the translation of the sample 170, the portions of the semiconductor thin film are irradiated and at least partially melted using a masked intensity pattern beam pulse to allow the irradiated portions to crystallize. This irradiation of these

30　portion of the semiconductor thin film 175 can be performed when the beam pulses reach particular locations on the sample, which are pre-assigned by the computing

arrangement 100. Thus, the beam source can be fired upon the sample reaching these locations with respect to the beam pulses. Thereafter, the irradiated portions of the semiconductor thin film are allowed to crystallize such that the certain areas of the solidified portions have been nucleated and include uniform material therein so as to

5   allow the distance between at least the active regions of the TFT devices to be greater that the edge regions of such irradiated areas. Such processing is continued until the end of the current column on the semiconductor thin film 175 is reached. In step 1145, it is determined whether there are any further columns of the sample to be processed. If so, the process continues to step 1150 in which the sample is translated

10   to that the beam pulse is pointed to the next column to be processed according to the present invention. Otherwise, in step 1155 is performed, which is substantially the same as that of step 1055 of Fig. 9.

The foregoing merely illustrates the principle s of the invention. Various modifications and alterations to the described embodiments will be apparent

15   to those skilled in the art in view of the teachings herein. For example, while the above embodiment has been described with respect to irradiation and crystallization of the semiconductor thin film, it may apply to other materials processing techniques, such as micro-machining, photo-ablation, and micro-patterning techniques, including those described in International patent application no. PCT/US01/12799 and U.S.

20   patent application serial nos. 09/390,535, 09/390,537 and 09/526,585, the entire disclosures of which are incorporated herein by reference. The various mask patterns and intensity beam patterns described in the above-referenced patent application can also be utilized with the process and system of the present invention. It will thus be appreciated that those skilled in the art will be able to devise numerous systems and

25   methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the present invention.

<u>What Is Claimed Is</u>:

1.   A method for processing a thin film sample, comprising the steps of:

(a)   controlling a beam generator to emit at least one beam pulse;

5   (b)   masking the at least one beam pulse to produce at least one masked beam pulse, wherein the at least one masked beam pulse is used to irradiate at least one portion of the thin film sample;

.   (c)   with the at least one masked beam pulse, irradiating the at least one portion of the film sample with sufficient intensity for the at least one portion to later

10   crystallize; and

(d)   allowing the at least one portion of the film sample to crystallize, the crystallized at least one portion being composed of a first area and a second area, wherein, upon the crystallization thereof, the first area includes a first set of grains, and the second area includes a second set of grains whose at least one characteristic is

15   different from at least one characteristic of the second set of grains,

wherein the first area surrounds the second area, and is configured to allow an active region of an electronic device to be provided at a distance therefrom.

2.   The method according to claim 1, wherein the masked beam pulse has the

20   intensity to completely melt the at least one portion of the thin film sample throughout its thickness.

3.   The method according to claim 1, wherein the masked beam pulse has the intensity to partially melt the at least one portion of the thin film sample.

25

4.   The method according to claim 1, wherein the active region of the TFT is situated within the second area.

5.   The method according to claim 1, wherein the second area corresponds to at

30   least one pixel.

6.   The method according to claim 1, wherein the second area has a cross-section for facilitating thereon all portions of the TFT.

7.   The method according to claim 1, wherein a size and a position of the first
area with respect to the second area are provided such that the first area provides either no effect or a negligible effect on a performance of the TFT.

8.   The method according to claim 1, further comprising the step of:
       (e)   after step (d), determining a location of the first area so as to avoid a
placement of the active region of the TFT thereon.

9.   The method according to claim 1, wherein the at least one beam pulse includes a plurality of beamlets, and wherein the first and second areas are irradiated by the beamlets.

10.   The method according to claim 1, wherein the thin film sample is a silicon thin film sample.

11.   The method according to claim 1, wherein the thin film sample is composed of
at least one of silicon and germanium.

12.   The method according to claim 1, wherein the thin film sample has a thickness approximately between 100Å and 10,000Å.

13.   The method according to claim 1, wherein the first set of grains provided in the first area are laterally-grown grains.

14.   The method according to claim 13, wherein the laterally-grown grains of the first area are equiaxed grains.

15.   The method according to claim 1, wherein the electronic device is a thin-film transistor ("TFT").

16.   The method according to claim 1, wherein the thin film sample is a
5   semiconductor thin film sample.

17.   A system for processing a thin film sample, comprising:

a processing arrangement which is configured to:

(a)   control a beam generator to emit at least one beam pulse;

10   (b)   mask the at least one beam pulse to produce at least one masked beam pulse, wherein the at least one masked beam pulse is used to irradiate at least one portion of the film sample; and

(c)   with the at least one masked beam pulse, initiate an irradiation of the at least one portion of the film sample with sufficient intensity for the at
15   least one portion to later crystallize

wherein the at least one portion of the film sample is allowed to crystallize, the crystallized at least one portion being composed of a first area and a second area, wherein, upon the crystallization thereof, the first area includes a first set of grains, and the second area includes a second set of grains whose at least one characteristic is
20   different from at least one characteristic of the second set of grains,

wherein the first area surrounds the second area, and configured to allow an active region of an electronic device to be provided at a distance therefrom.

18.   The system according to claim 17, wherein the masked beam pulse has the
25   intensity to completely melt the at least one portion of the thin film sample throughout its thickness.

19.   The system according to claim 18, wherein the masked beam pulse has the intensity to partially melt the at least one portion of the thin film sample.

30

20.	The system according to claim 17, wherein the active region of the TFT is situated within the second area.

21.	The system according to claim 17, wherein the second area corresponds to at least one pixel.

22.	The system according to claim 17, wherein the second area has a cross-section for facilitating thereon all portions of the TFT.

23.	The system according to claim 17, wherein a size and a position of the first area with respect to the second area are provided such that the first area provides either no effect or a negligible effect on a performance of the TFT.

24.	The system according to claim 17, wherein the processing arrangement is further configured to, after procedure (d), determine a location of the first area so as to avoid a placement of the active region of the TFT thereon.

25.	The system according to claim 17, wherein the at least one beam pulse includes a plurality of beamlets, and wherein the first and second areas are irradiated by the beamlets.

26.	The system according to claim 17, wherein the thin film sample is a silicon the film sample.

27.	The system according to claim 17, wherein the thin film sample is composed of at least one of silicon and germanium.

28.	The system according to claim 17, wherein the thin film sample has a thickness approximately between 100Å and 10,000Å.

29.   The system according to claim 17, wherein the first set of grains provided in the first area are laterally-grown grains.

30.   The system according to claim 29, wherein the laterally-grown grains of the

5   first area are equiaxed grains.

31.   The system according to claim 17, wherein the electronic device is a thin-film transistor ("TFT").

10   32.   The system according to claim 17, wherein the thin film sample is a semiconductor thin film sample.

33.   A thin film sample, comprising:
            at least one section irradiated by at least one masked beam pulse which

15   is configured to irradiate the at least one section of the sample for a later crystallization thereof,
            wherein the at least one portion of the film sample is crystallized to include a first area and a second area,
            wherein, upon the crystallization thereof, the first area includes a first set of

20   grains, and the second area includes a second set of grains whose at least one characteristic is different from at least one characteristic of the second set of grains,
            wherein the first area surrounds the second area, and is configured to allow an active region of an electronic device to be provided at a distance therefrom.
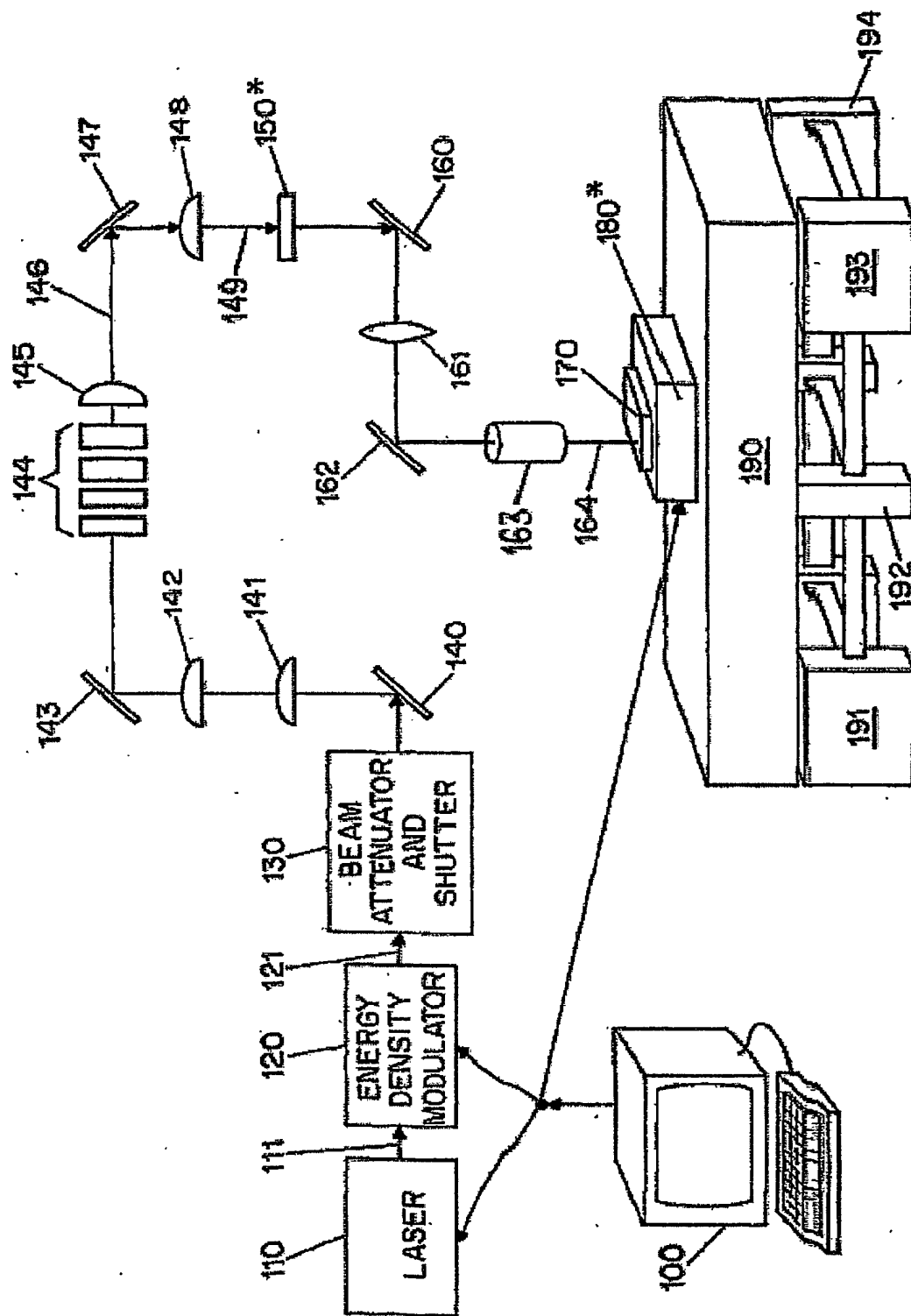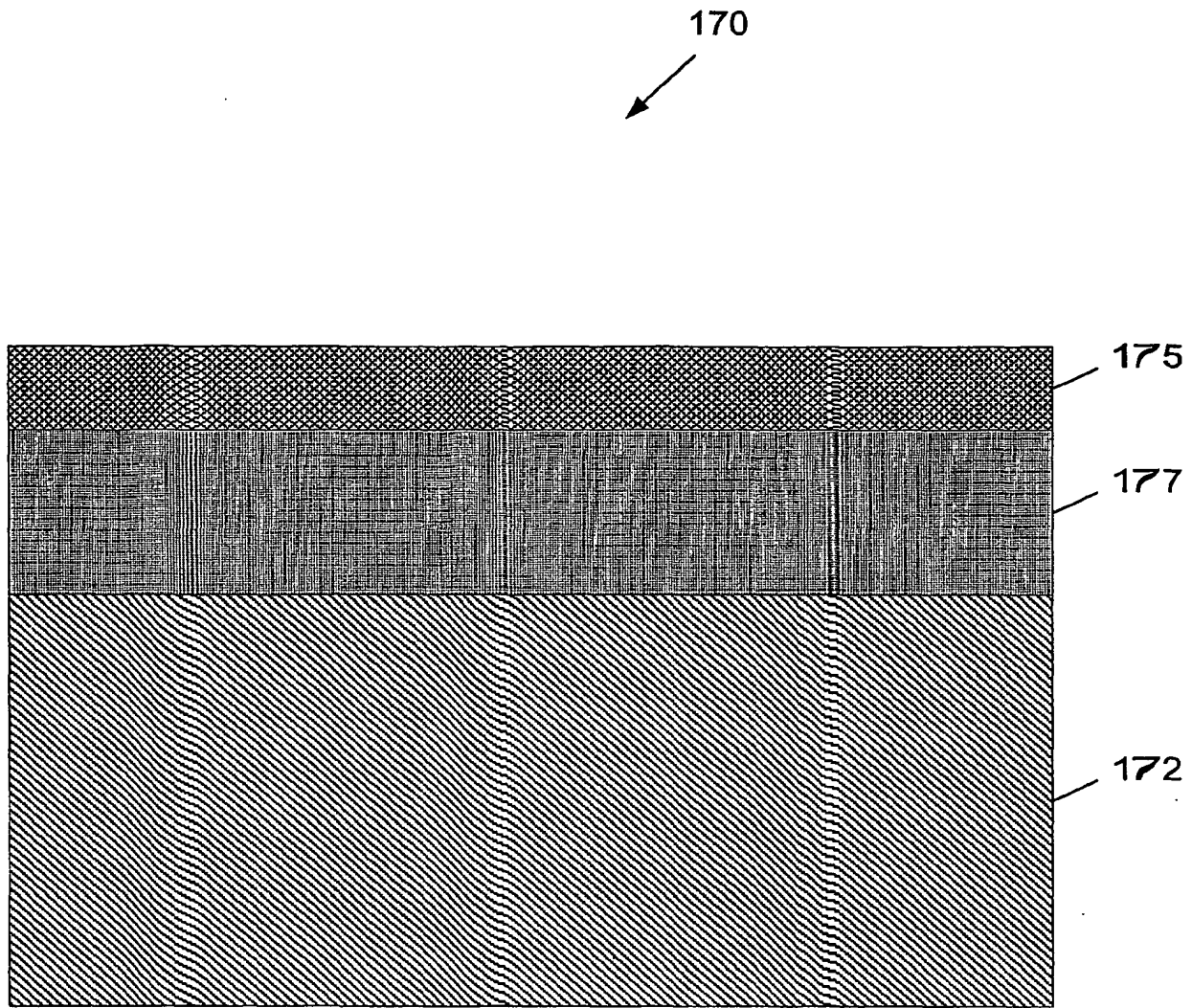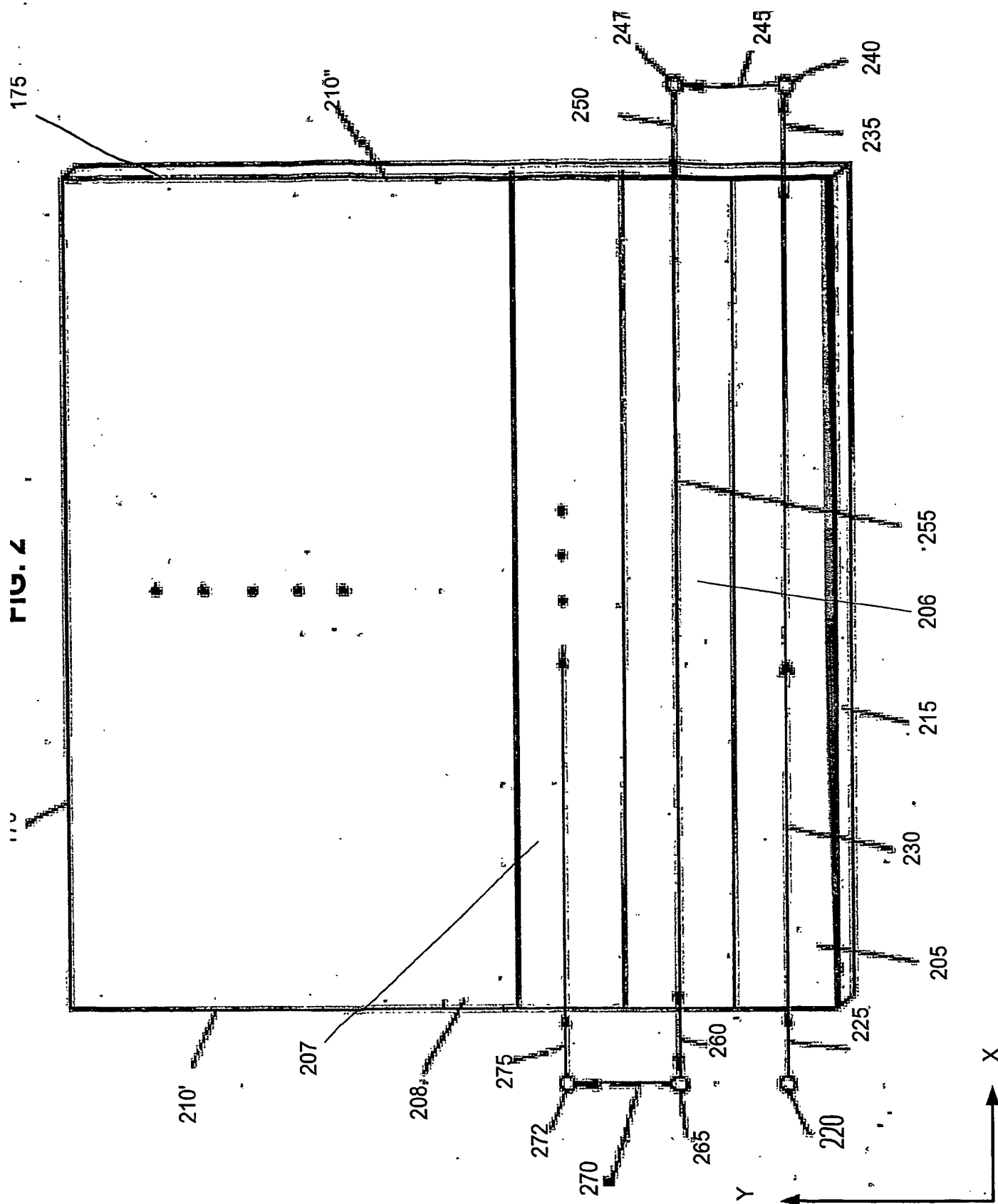
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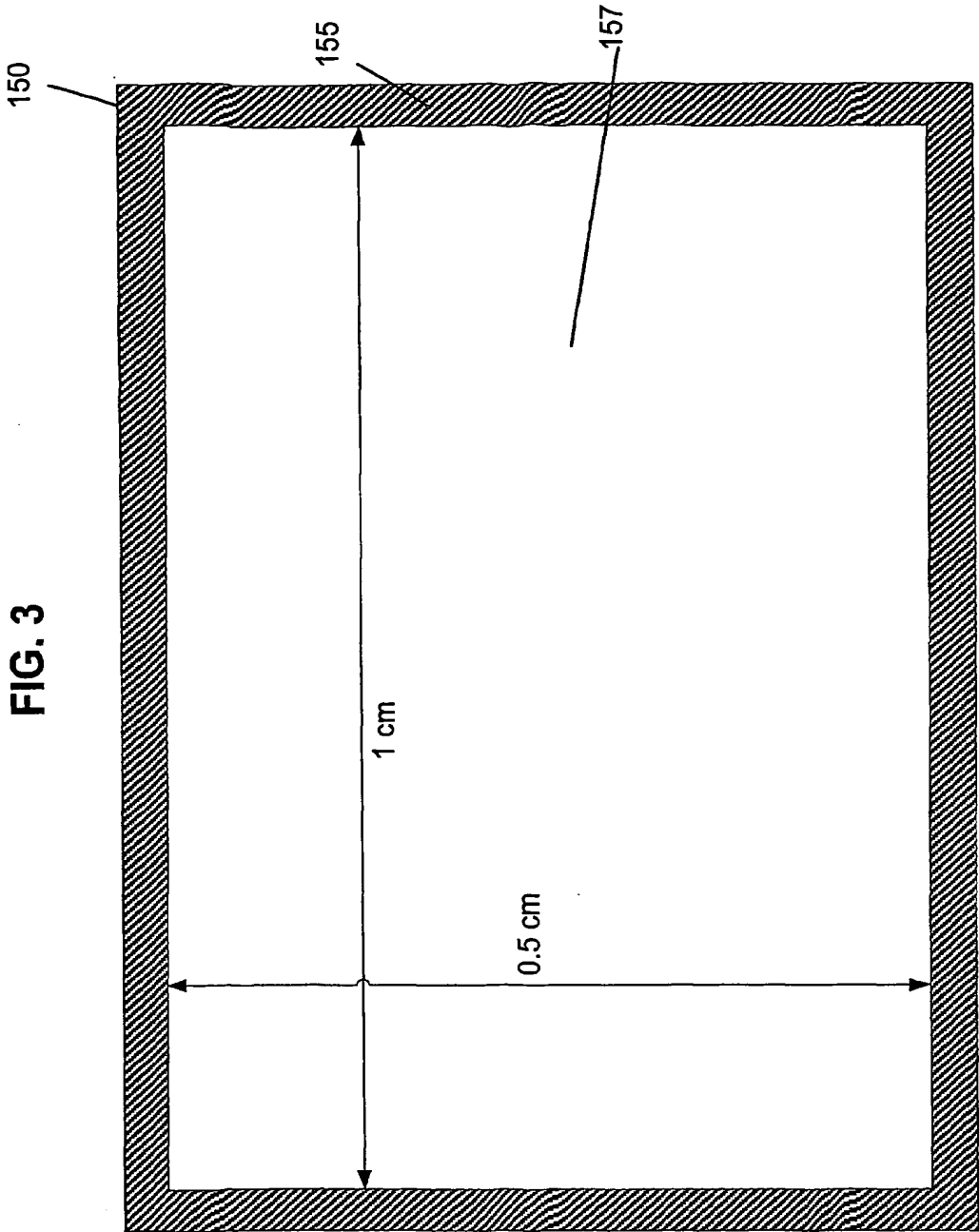
FIG. 1A

170

175

177

172

FIG. 1B

FIG. 2

FIG. 3

FIG. 4A

FIG. 4B

FIG. 4C

FIG. 4D

FIG. 4-E

FIG. 4F

FIG. 5A

455 455

450 450

150'

FIG. 5B

450

0.5µm

0.5µm

175

210'

FIG. 6A

462

Y

X

460

175

210'

FIG. 6B

462

465

468

Y

X

460

175

FIG. 6C

462

465

468

210"

X   460   470
              472

175

FIG. 6D

462

465

468

210"

X   460   475   478   470
              472

175

170

X

164

150"

490

0.5μm

0.5 cm

FIG. 7

FIG. 8A

610

614

612

650

620

624

612

DRAIN

GATE

ACTIVE REGION

DRAIN

GATE

ACTIVE REGION

SOURCE

SOURCE

618

616

518 510

515

500

628

626

528 520

525

640

FIG. 8B

610'

614'

DRAIN

650

620'

624'

DRAIN

612'

622'

GATE

ACTIVE REGION

ACTIVE REGION

GATE

618'

SOURCE

518 510

515

500

660

628'

SOURCE

528 520

525

616'

626'

FIG. 9

START → INITIALIZE HARDWARE —— 1000

↓

LOAD SAMPLE —— 1005

↓

MOVE STAGE TO INITIAL POSITION —— 1010

↓

ADJUST FOCUS AND ALIGNMENT OF OPTICAL SYSTEM, IF NECESSARY —— 1015

↓

STABILIZE LASER AT DESIRED RADIATION BEAM PULSE ENERGY LEVEL AND REPETITION RATE —— 1020

↓

1 024

EACH PULSE HAS SUFFICIENT ENERGY TO AT LEAST PARTIALLY MELT IRRADIATED PORTION OF SEMICONDUCTOR THIN FILM SO IT CRYSTALLIZES?

NO → ADJUST TTENUATION

YES

↓

POSITION SAMPLE TO POINT THE BEAM TO IMPINGE A FIRST COLUMN OF SAMPLE —— 1027

↓

IRRADIATE SAMPLE WITH FIRST RADIATION BEAM PULSE HAVING MASKED INTENSITY PATTERN OR SHAPED BEAM —— 1030

↓

IS THE IRRADIATION FOR THE CURRENT COLUMN COMPLETED? —— 1035

NO → RRADIATE SAMPLE WITH NEXT RADIATION BEAM PULSE HAVING MASKED INTENSITY PATTERN OR SHAPED BEAM —— 1040

YES

↓

ANY MORE COLUMNS OF SAMPLE TO BE IRRADIATED FOR PROCESSING? —— 1045

YES → SHUT OFF RADIATION BEAM AND HARDWARE —— 1055 → STOP

NO → TRANSLATE SAMPLE SO THAT THE BEAM IS POINTED TO THE NEXT COLUMN FOR CRYSTALLIZATION PROCESSING —— 1050

FIG. 10

START → INITIALIZE HARDWARE — 1100

LOAD SAMPLE — 1105

MOVE STAGE TO INITIAL POSITION — 1110

ADJUST FOCUS AND ALIGNMENT OF OPTICAL SYSTEM, IF NECESSARY — 1115

STABILIZE LASER AT DESIRED RADIATION BEAM PULSE ENERGY LEVEL AND REPETITION RATE — 1120

1125

ADJUST ATTENUATION ← NO —

1124

EACH PULSE HAS SUFFICIENT ENERGY TO AT LEAST PARTIALLY MELT IRRADIATED PORTIONS OF SEMICONDUCTOR THIN FILM WITHOUT OVERMELTING?

YES

POSITION SAMPLE TO POINT THE BEAM TO IMPINGE A FIRST COLUMN OF SAMPLE — 1127

MASK BEAM TO GENERATE MASKED BEAM PULSE — 1130

CONTINUOUSLY TRANSLATE SAMPLE ALONG CURRENT COLUMN — 1135

1140
DURING TRANSLATION OF SAMPLE, EFFECTUATE THE IRRADIATION OF SAMPLE WITH RADIATION BEAM PULSE HAVING MASKED INTENSITY PATTERN OR WITH SHAPED BEAM WHEN BEAM REACHED PREDETERMINED LOCATIONS WITH RESPECT TO SAMPLE

TRANSLATE SAMPLE SO THAT THE BEAM IS POINTED TO THE NEXT COLUMN FOR LATERAL SOLIDIFICATION PROCESSING

1150

1155

SHUT OFF RADIATION BEAM AND HARDWARE ← YES —

ANY MORE COLUMNS OF SAMPLE TO BE IRRADIATED FOR PROCESSING? — NO

1145

STOP

Fig. 11 A
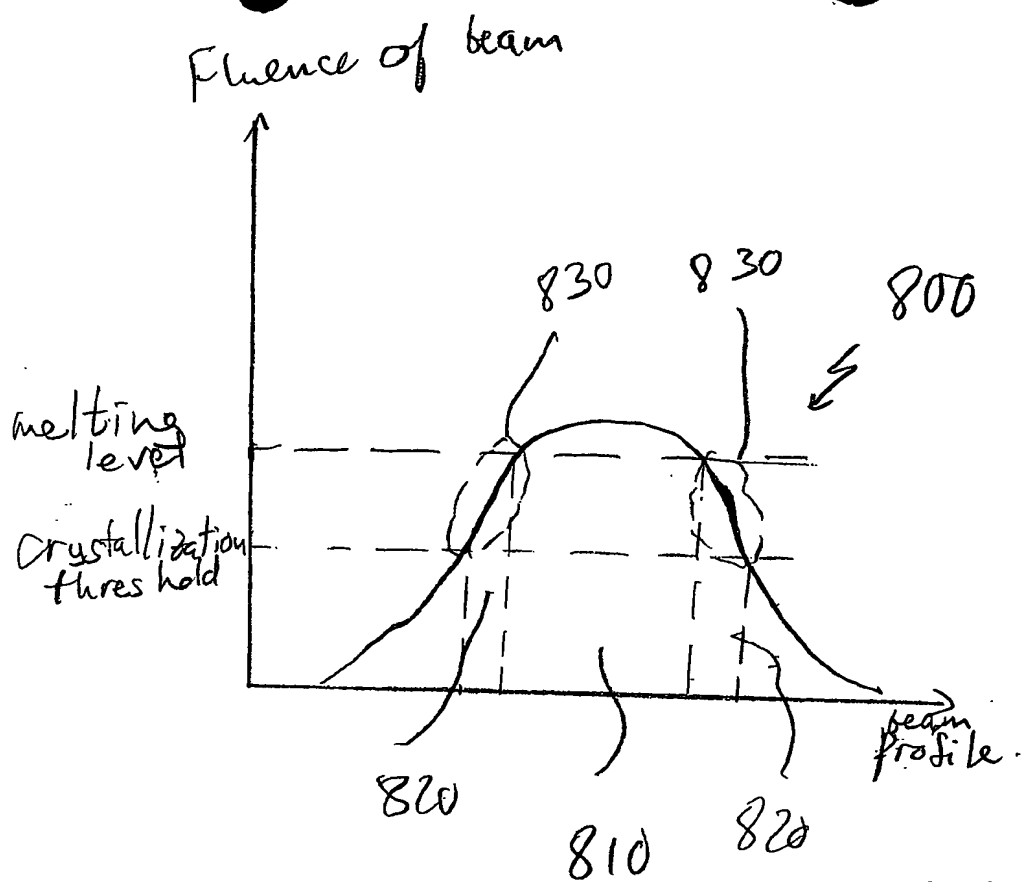Prior Art

Fluence of beam

830   830   800

melting
level

Crystallization
threshold

820

810   820

beam
profile

Fig. 11B   Prior Art

Fluence of
Beam

850

melting
level

Beam
Profile

Fig. 12